MOOSE POPULATION RESEARCH AND MANAGEMENT STUDIES IN YUKON

PREDATOR IDENTIFICATION AT MOOSE CALF MORTALITY SITES, SOUTHWEST YUKON

by
David A. Gauthier
and
Douglas G. Larsen

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PREDATOR IDENTIFICATION AT MOOSE CALF MORTALITY SITES, SOUTHWEST YUKON

D.A. Gauthier[1]

D.G. Larsen[2]

[1]Dept. of Geography, University of Regina, Regina, Saskatchewan

[2]Yukon Dept. of Renewable Resources, Whitehorse, Yukon

Director, Fish & Wildlife Branch

Senior Big Game Biologist

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ABSTRACT

Identification of large predators (bears and wolves) at ungulate mortality sites is often based on indirect evidence. Sign at moose calf mortality sites at which the identity of the predator was known from visual observations was categorized as either "bear" or "wolf" based on eight variables collected in 1983 and 1985. Bear hair occurred at 83% of kills attributed to bears, while 29% and 64% of bear kill sites contained bear tracks and scats, respectively. Wolf hair was found at 94% of wolf kill sites and 56% and 50% of wolf kill sites contained wolf tracks and scats, respectively. Calf carcasses were buried at 68% and 0% of bear and wolf kill sites, respectively. Carcass stomach contents were absent at 85% of bear kill sites and 44% of wolf sites. Ninety percent or more of the calf hide was present at 46% of bear kill sites but at only 6% of wolf sites. The remains of moose calves killed by wolves were spread over a larger distance than those killed by bears. Information was also collected on the percent of calf remains present at mortality sites. Multiple linear regressions were used to develop predictive equations describing the relationships of the two predator groups to the eight variables in 1983. The site-specific data from 1985 was input into the "best" of several equations to predict the likely predator in 1985. The accuracy of the prediction was assessed by comparing the predicted to the observed predator. A six-variable equation accurately predicted the right predator in all cases where the predator was observed in 1985. We conclude that collection of sign at kill sites can provide an accurate means of estimating predator identity in cases where the predator is not visually identified.

INTRODUCTION

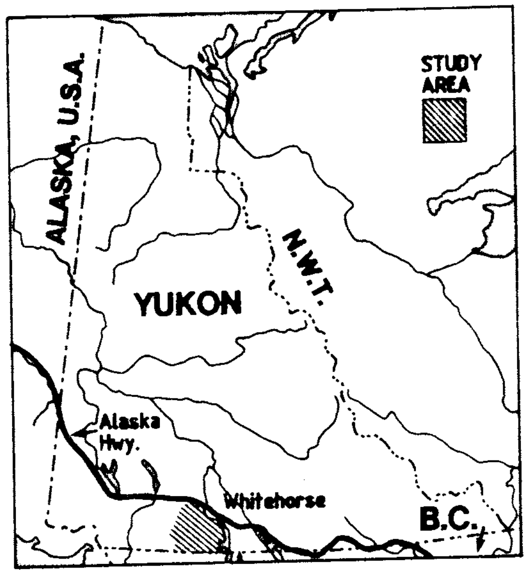
Grizzly bears (Ursus arctos), black bears (Ursus americanus) and wolves (Canis lupus) have been identified as important predators of moose (Alces alces)

(Franzmann et al. 1980, Ballard et al. 1981, Stewart et al. 1985, Gasaway et al. 1983, 1986). Since large predators are rarely observed in the act of killing their ungulate prey, researchers have to rely on indirect evidence to determine predator identity. Even a visual sighting of a predator at a kill site may identify only a scavenger rather than the actual predator. However, telemetric monitoring of moose calves combined with visual sightings of predators and predator sign at the kill site may provide a reasonably accurate picture of predator identity. In this paper, we report on the evidence of predation at moose calf kill sites from May to August of 1983 and 1985 in southwest Yukon. This study was part of a larger study of the causes and rates of moose mortality in southern Yukon (Larsen et al, 1987).

STUDY AREA

The study area, comprising 6,310 km^2 of southwest Yukon, is located adjacent to the British Columbia - Yukon border (Fig. 1). The area is characterized by extensive alpine and subalpine habitats with 76% of the area above treeline (1,200 m). Thirty percent of the study area was considered unsuitable habitat (i.e. precipitous slopes, icefields, rocky areas above 1,500 m and large water bodies) for moose (Larsen 1982). The vegetation reflects differences in physiography, weather, and fire history. Lichens and graminoids occur on lower exposed alpine slopes, and shrub birch (Betula spp.) and willows (Salix spp.) colonize subalpine and lowland riparian habitats. Scattered white spruce (Picea glauca) dominate lower subalpine elevations and extend into valley bottoms where lodge-pole pine (Pinus contorta) are prevalent. Paper birch (Betula papyrifera) and poplar (Populus spp.) are scattered throughout valley floors. Forest fires have been suppressed in this area for at least the past two decades. The climate is cool and dry. Physiography, vegetation and climate of this area have been described in more detail by Oswald and Senyk (1972) and Davies et al. (1983).

Figure 1. Southwest Yukon Study Area



Large predators in the study area include wolves, grizzly bears and black bears. Mid-winter wolf densities were approximately 13 wolves/1,000 km^2 of the total land area in 1982 (Hayes et al. 1985). Larsen and Markel (1986) estimated a grizzly bear population density of 16 bears/1,000 km^2 for the study area in 1985. Black bear populations occur sporadically in low elevation forest habitat. Densities are unknown, but are most likely similar to or less than grizzly bear densities based on estimates of available habitat. The major prey species are moose, caribou (Rangifer tarandus) and Dall's sheep (Ovis dalli). Fall surveys indicate low moose densities at 190 moose/1,000 km^2 (Johnston et al. 1984) and fall caribou at 20/1,000 km^2 (Farnell, pers. comm.). Dall's sheep are the most abundant ungulate in the study area at 300/1,000 km^2 (Barichello, pers. comm.). Other prey species include snowshoe hare (Lepus americanus) and beaver (Castor canadensis). Hare numbers were low throughout Yukon in 1983 (Slough 1984), reaching densities of 20 hares/1000 km^2 in southwest Yukon (Boutin et al. 1986, Ward and Krebs 1985). Beaver were common (3-12 km of stream/active colony) in the northeast corner of the study area (Slough and Jessup 1984), but likely uncommon in the remainder of the study area, based on physiography and available habitat.

METHODS

Forty-four cow moose were radio-collared (Telonics, Mesa, Arizona) in March 1983-84 and monitored daily through the moose calving period (15 May to 10 June) in 1983 and 1985, using telemetry equipment aboard a helicopter or fixed-wing aircraft. When a radio-collared cow or uncollared cow was observed with a calf, the helicopter landed and the single calf or twins were live-captured. One hundred-and-nineteen calves were radio-collared. Collared calves were between a few hours and 7-days-old, and the mean age of calves at collaring was 2-days-old (Larsen et al. 1987). Calf collars were equipped with motion sensors; activation 2 hours after movement of the calf ceased indicated possible mortality. Collared calves were monitored 1-3 times/day during 15 May to 3 July and once/week through July and August. All collared calf mortalities were examined immediately upon receiving a mortality signal and likely within 12 hours of death during May to July and no later than 1 week from mortality during July and August. Ten of the 77 mortalities analyzed in this study occurred in July and August.

Mortality sites were surveyed within a radius of 1.0 km by helicopter for predators. In addition to sightings of predators, ground crews measured 8 variables at the mortality sites to document cause of calf mortality: 1) presence of bear or wolf hair; 2) presence of bear or wolf tracks; 3) presence of bear or wolf scats (feces) within a 100 m radius of the kill site; 4) whether the carcass was buried; 5) percent of the carcass hide present; 6) whether the prey stomach contents were present; 7) percent of the carcass found; and 8) radius of the area where the observable carcass was spread. Hair samples distinguished based on colour, texture, medullar and cuticle scale patterns (Adjordan and Kolenosky 1969, Kennedy and Carbyn 1981). Scats were identified as either bear or wolf based on size and shape characteristics. The percent hide and carcass remaining were visually estimated.

Based on a visual sighting of a predator at a mortality site and the occurrence of the 8 site characteristics, the cause of each mortality in 1983 and 1985 was classified as "wolf", "bear" or unknown. Mortality sites where more than 1 predator species was observed or sign was present (N=8) were not used to describe site characteristics. We contend that predators observed at or near moose calf mortality sites caused the mortality and were not simply scavengers, based on the following:

1) Moose calves were monitored 3 times a day and located no later than 12 hours from the time of death in 67 of 77 cases.
2) Work in southcentral Alaska (Ballard et al. 1981, where predator-prey densities were similar to those in this study, suggests that large predators/scavengers do not usually find a moose calf carcass until at least 30 hours to several days after death. A comparable study on the Kenai Peninsula (Franzmann et al. 1980) found that calves were not scavenged by wolves and bears within 1 day of death, nor were calves that were checked 8-10 days after death scavenged by wolves or bears. However, Gasaway et al. (1986) documented scavenging of wolf killed moose ($\geq$ 1 year) by grizzly bears within 2-5 days of death.

3) There is evidence from a number of studies to show that grizzly bears are not important scavengers. Studies in eastcentral Alaska found that grizzly bears were primarily predators, not scavengers, in areas of low moose density (Boertje et al. 1988). Those findings agree with other studies (Ballard et al. 1981; Franzmann et al. 1980). In addition, Boertje et al. (1985) concluded that dead moose calves attended by grizzly bears were killed by bears based on evidence from necropsied calves.
4) When a bear or wolf kill a calf they usually leave sign.
5) Sign of only 1 predator species was found at each mortality site.

Therefore, we believe it is valid in this study to assign the cause of mortality to the predator seen at or near the mortality site.

Contingency table analysis using the log-likelihood-ratio test (Sokal and Rohlf 1981) was used to test the statistical difference of frequency classes of variables. Multiple linear regressions of the form $Y=B(0) + B(1)x(1) + B(2)x(2) + \ldots + B(n)x(n) + E$ were used to develop predictive equations describing the relationships of the 2 predators to the 8 mortality site characteristics in 1983. All possible regressions were conducted using the maximum coefficient of multiple determination (R-square) and the minimum Mallow's C(p) statistic as criteria for selection (Daniel and Wood 1980, Montgomery and Peek 1982). The backward elimination and maximum R-square improvement techniques were used to define the "best" 1-variable equation, the "best" 2-variable equation and so forth to the complete 8-variable equation. We then input the appropriate data from the 8 measured variables from mortality sites in 1985 into each of the "best" equations to predict the likely predator. The predicted predator was compared with the observed predator for sites in 1985, where a visual sighting of a predator had been made. Colinearity among the 8 mortality site characteristics was assessed first through correlation analysis and then through variance inflation and decomposition analysis; non-linearity among the response and regressor variables was assessed through the partial plot technique (predicting the response using all the regressors, except 1 and then plotting the resultant residuals against the omitted regressor) (SAS Institute 1985).

RESULTS AND DISCUSSION

Table 1 shows the frequency of mortality site characteristics attributed to the 2 predator species for 1983 and 1985, and Table 2 illustrates mean and standard error levels for numeric variables. Predators were observed at 39% of the sites investigated, and bears accounted for 90% of the predator observations. In all but 1 of these latter instances, the bear was either covering the carcass with dirt and vegetation, resting beside the carcass, or walking a short distance from the kill. In the 1 exception, a sow with 2 yearlings chased and killed a calf.

Bear hair was found at 83% of kills attributed to bears, and 29% and 64% of bear kill sites contained bear tracks and scats, respectively. In contrast, wolf hair was found at 94% of wolf kill sites, and 56% and 50% of wolf kill sites contained wolf tracks and scats, respectively. Calf carcasses were buried at 68% and 0% of the bear and wolf kill sites, respectively ($G=32.5$; $p < 0.01$). Carcass stomach contents were absent at 85% of bear kill sites and 47% of wolf sites, a statistically significant difference ($G=9.3$; $p < 0.01$). Ninety percent or more of the calf hide was present at 46% of bear kill sites, but at only 6% of wolf sites. On the basis of cell chi-square values, the significant difference ($G=11.9$; $p < 0.01$) between the 2 predator groups in terms of % hide present was largely due to differences in the frequency with

Table 1. **Summary of occurrences of predator sign at moose calf mortality sites, southwest Yukon, 1983 and 1985.**

Sign at moose calf mortality sites	Grizzly & black bear kills of moose calves		Wolf kills of moose calves	
	1983 (n=39)	1985 (n=20)	1983 (n=11)	1985 (n=7)
Predator(s) sighted:				
wolf	0	0	2	1
bear	17	10	0	0
none	22	10	9	6
Predator hair type:				
bear	33	16	0	0
wolf	0	0	11	6
no hair	6	4	0	1
Predator track type:				
bear	14	3	0	0
wolf	0	0	8	2
no tracks	25	17	3	5
Predator scat type:				
bear	29	9	0	0
wolf	0	0	6	3
no scats	10	11	5	4
Buried:				
buried	27	13	0	0
not buried	12	7	11	7
% prey hide present:				
≤ 10%	17	9	7	7
11-89%	3	3	3	0
≥ 90%	19	8	1	0
Prey's stomach:				
absent	34	16	2	6
present	5	4	8	1
not recorded	0	0	1	0
% prey found:				
0-15%	27	13	10	7
16-29%	2	1	1	0
≥ 30%	10	6	0	0
Radius of carcass spread:				
0-99m	37	17	5	5
100-199m	2	2	2	0
200-299m	0	0	1	0
≥ 300m	0	1	3	0
not recorded	0	0	0	2

Table 2. Summary statistics for selected moose calf kill site characteristics, southwest Yukon, 1983 and 1985 (combined).

Sign at moose calf mortality sites	Grizzly and black bear kills of moose calves (mean ± standard error) (N=59)	Wolf kills of moose calves (mean ± standard error) (N=18)
% prey hide present	50.5 ± 6.1	14.3 ± 6.7
% of prey found	23.0 ± 4.3	3.7 ± 1.2
Radius of carcass spread (m)	18.2 ± 6.5	122.2 ± 30.1

which 90% or more of hide occurred at kill sites. Grizzly bears tended to "skin" a calf moose carcass leaving much of the hide intact, in contrast to wolves who tore or shredded hides from the carcass. Calf hides at bear kill sites were often inverted. The lack of hide ingested by bears would result in the absence of hair in the bear scat. This was the case with bear scats observed at kill sites. Typically, a pile of bones, the hide and the radio collar were found at the burial site. The ribs, scapula, lower jaw bones, cranial bones and leg bones were often found, as well as the detached hoof sheathes. Several scat piles and beds were often found and a musky odour was present.

Unlike bears, wolves scattered the carcass over a wide area, at least 300m from the kill site, and tended to crush all of the bones, except for the heavier parts of the leg bones and mandibles. Several small bone piles or individual bones were found in the general area. The radio collar of the dead calf was often found 50-100m from the nearest predator evidence. The mean radius of carcass spread by wolves was significantly greater ($p < 0.01$) than by bears.

The results from this study are similar to those reported from southcentral Alaska by Ballard et al. (1979, 1981). In that study, predators were observed at 48% of the kill sites and bears observed at 79% of those sites. Predator hair was found at all kills, while tracks and scats were common. Lower jaw and cranial bones were often present at grizzly kills, while bones at wolf kills tended to be scattered. Viscera from the prey was present in most wolf kills and missing at grizzly kills. Calf hide was present on approximately one half of the calf carcasses. The results from Ballard et al. (1979) differ from the present study in the following: calf brains, ears, eyes and tongues were often missing at grizzly kills in the Alaskan study and rarely missing in our study. Also, carcasses were buried in only 25% of the bear kills in southcentral Alaska compared to 68% in this study.

Table 3 shows the 8 "best-fit" models derived from stepwise multiple regression analysis with their respective R-square and C(p) values. On the basis of the highest coefficient of multiple determination (R-square) and the lowest Mallows' C(p) statistic, Model 6 (R-square of 94%, the proportion of the variance explained by the regressors) is the preferred model for predicting predator identity at moose calf kill sites in southwest Yukon. The kill site data for 1985 were input to Model 6 to derive a "predicted" predator. The model predicted correctly all 7 cases of wolf predation and all 20 cases of bear predation. Model 1 (predator hair, explaining 83% of the variation in the data), also predicted the predator in each case.

Results suggest that the combination of frequent telemetric monitoring of calves combined with collection of sign at kill sites provides an accurate means of estimating predator identity in cases where visual identification of the predator is not made. Also, these results suggest that the single most accurate sign was the presence of hair left by the predator. We caution that the technique is only appropriate where 1 predator visited the mortality site. We were unable to test the predictability of predator identities where multiple predator species sign existed, nor were we able to distinguish between black and grizzly bear sign. These situations would require substantially more complex interpretation.

Table 3. "Best" predictive models of predator identity at moose calf kill sites, southwest Yukon, based on stepwise multiple regression analyses and R-square and Mallow's C(p) criteria for selection.

No. of variables and Model number	Model Component(s)	R-square	C(p)
1	Predator hair type	0.83	61.34
2	Predator hair, tracks	0.90	20.47
3	Predator hair, tracks, spread of carcass	0.92	12.28
4	Predator hair, tracks, spread of carcass, scats	0.93	8.63
5	Predator hair, tracks, spread of carcass, scats, percent hide present	0.93	7.57
6	Predator hair, tracks, spread of carcass, percent hide present, percent of carcass found, carcass buried or not buried	0.94	7.01
7	Predator hair, tracks, spread of carcass, percent hide present, percent of carcass found, carcass buried or not buried, stomach contents present or absent	0.94	7.77
8	All variables	0.94	9.00

ACKNOWLEDGMENTS

We thank R. Boertje (Alaska Fish and Game) for reviewing an earlier draft of this paper. We appreciate the field assistance of R. Markel, P. Merchant, B. Hayes, P. Dennison and other Yukon Fish and Wildlife staff. Dr. G. Glover, Veterinarian College, University of Saskatoon, assisted with the immobilization of adult female moose. P. Merchant identified predator hair.

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David A. Gauthier
Department of Geography
University of Regina
Regina, Saskatchewan
306-584-4154

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DAVID A. GAUTHIER, Department of Geography, University of Regina, Saskatchewan S4S 0A2S

DOUGLAS G. LARSEN, Yukon Department of Renewable resources, Whitehorse, Yukon Y1A 2C6

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Key words: *Alces alces*, bears, moose mortality, predation, radio-telemetry, wolf, Yukon.

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(Fig. 1). The area is characterized by extensive alpine and subalpine habitats with 76% of the area above treeline (1,200 m). Thirty percent of the study area was considered unsuitable habitat (i.e. precipitous slopes, icefields, rocky areas above 1,500 m and large water bodies) for moose (Larsen 1982). The vegetation reflects differences in physiography, weather, and fire history. Lichens and graminoids occur on lower exposed alpine slopes, and shrub birch (*Betula* spp.) and willows (*Salix* spp.) colonize subalpine and lowland riparian habitats. Scattered white spruce (*Picea glauca*) dominate lower subalpine elevations and extend into valley bottoms where lodge-pole pine (*Pinus contorta*) are prevalent. Paper birch (*Betula papyrifera*) and poplar (*Populus* spp.) are scattered throughout valley floors. Forest fires have been suppressed in this area for at least the past 2 decades. The climate is cool and dry. Physiography, vegetation and climate of this area have been described in more detail by Oswald and Senyk (1972) and Davies et al. (1983).

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Forty-four cow moose were radio-collared (Telonics, Mesa, Arizona) in March 1983-84 and monitored daily through the moose calving period (15 May to 10 June) in 1983 and

1985, using telemetry equipment aboard a helicopter or fixed-wing aircraft. When a radio-collared cow or uncollared cow was observed with a calf, the helicopter landed and the single calf or twins were live-captured. One hundred-and-nineteen calves were radio-collared. Collared calves were between a few hours and 7-days-old, and the mean age of calves at collaring was 2-days-old (D. G. Larsen, Yukon Territ., unpubl. data). Calf collars were equipped with motion sensors; activation 2 hours after movement of the calf ceased indicated possible mortality. Collared calves were monitored 1 - 3 three times/day during 15 May to 3 July and once/week through July and August. All collared calf mortalities were examined immediately upon receiving a mortality signal and likely within 12 hours of death during May to July and no later than 1 week from mortality during July and August. Ten of the 77 mortalities analyzed in this study occurred in July and August.

Mortality sites were surveyed within a radius of 1.0 km by helicopter for predators. In addition to sightings of predators, ground crews measured 8 variables at the mortality sites to document cause of calf mortality: (1) presence of bear or wolf hair; (2) presence of bear or wolf tracks; (3) presence of bear or wolf scats (feces) within a 100 m radius of the kill site; (4) whether the carcass was buried; (5)

percent of the carcass hide present; (6) whether the prey stomach contents were present; (7) percent of the carcass found; and (8) radius of the area where the observable carcass was spread. Hair samples were distinguished based on colour, texture, medullar and cuticle scale patterns (Adjordan and Kolenosky 1969, Kennedy and Carbyn 1981). Scats were identified as either bear or wolf based on size and shape characteristics. The percent hide and carcass remaining were visually estimated.

Based on a visual sighting of a predator at a mortality site and the occurrence of the 8 site characteristics, the cause of each mortality in 1983 and 1985 was classified as "wolf", "bear" or unknown. Mortality sites where more than 1 predator species was observed or sign was present ($\underline{n}$=8) were not used to describe site characteristics. We contend that predators observed at or near moose calf mortality sites caused the mortality and were not simply scavengers, based on the following:

1. Moose calves were monitored 3 times/day and located no later than 12 hours from the time of death in 67 of 77 cases.
2. Work in southcentral Alaska (Ballard et al. 1981), where predator-prey densities were similar to those in this study, suggests that large predators/scavengers do not

usually find a moose calf carcass until at least 30 hours to several days after death. A comparable study on the Kenai Peninsula (Franzmann et al. 1980) found that calves were not scavenged by wolves and bears within 1 day of death, nor were calves that were checked 8-10 days after death scavenged by wolves or bears. Gasaway et al. (1986) documented scavenging of wolf killed moose ($\geq$ 1 year) by grizzly bears within 2-5 days of death.

3. There is evidence from a number of studies to show that grizzly bears are not important scavengers. Studies in eastcentral Alaska found that grizzly bears are primarily predators, not scavengers, in areas of low moose density (Boertje et al. 1988). Those findings agree with other studies (Ballard et al. 1981; Franzmann et al. 1980). In addition, Boertje et al. (1985) concluded that dead moose calves attended by grizzly bears were killed by bears based on evidence from necropsied calves.
4. When a bear or wolf kill a calf they usually leave sign.
5. Sign of only 1 predator species was found at each mortality site.

Therefore, we believe it is valid in this study to assign the cause of mortality to the predator seen at or near the mortality site.

Contingency table analysis using the log-likelihood-ratio test (Sokal and Rohlf 1981) was used to test the statistical difference of frequency classes of variables. Multiple linear regressions of the form $Y=B(0) + B(1)x(1) + B(2)x(2) + \ldots + B(n)x(n) + E$ were used to develop predictive equations describing the relationships of the 2 predators to the 8 mortality site characteristics in 1983. All possible regressions were conducted using the maximum coefficient of multiple determination (R-square) and the minimum Mallow's $C(p)$ statistic as criteria for selection (Daniel and Wood 1980, Montgomery and Peck 1982). The backward elimination and maximum R-square improvement techniques were used to define the "best" 1-variable equation, the "best" 2-variable equation and so forth to the complete 8-variable equation. We then input the appropriate data from the 8 measured variables from mortality sites in 1985 into each of the "best" equations to predict the likely predator. The predicted predator was compared with the observed predator for sites in 1985, where a visual sighting of a predator had been made. Colinearity among the 8 mortality site characteristics was assessed first through correlation analysis and then through variance inflation and decomposition analysis; non-linearity among the response and regressor variables was assessed through the partial plot technique (predicting the response using all the regressors, except 1 and then plotting the resultant residuals against the omitted regressor) (SAS Institute 1985).

RESULTS

Table 1 shows the frequency of mortality site characteristics attributed to the 2 predator species for 1983 and 1985, and Table 2 illustrates mean and standard error levels for numeric variables. Predators were observed at 39% of the sites investigated, and bears accounted for 90% of the predator observations. In all but 1 of these latter instances, the bear was either covering the carcass with dirt and vegetation, resting beside the carcass, or walking a short distance from the kill. In the 1 exception, a sow with 2 yearlings chased and killed a calf.

Bear hair was found at 83% of kills attributed to bears, and 29% and 64% of bear kill sites contained bear tracks and scats, respectively. In contrast, wolf hair was found at 94% of wolf kill sites, and 56% and 50% of wolf kill sites contained wolf tracks and scats, respectively. Calf carcasses were buried at 68% and 0% of the bear and wolf kill sites, respectively (G=32.5; $p < 0.01$). Carcass stomach contents were absent at 85% of bear kill sites and 47% of wolf sites, a statistically significant difference (G=9.3; $p < 0.01$). Ninety percent or more of the calf hide was present at 46% of bear kill sites, but at only 6% of wolf sites. On the basis of cell chi-square values, the significant difference (G=11.9; $p < 0.01$) between the 2 predator groups in terms of % hide present was largely due to differences in the frequency with which 90% or more of hide occurred at kill sites. Grizzly bears tended to "skin" a calf moose carcass leaving much of the hide intact, in contrast to wolves who tore or shredded hides from the carcass. Calf hides at bear kill sites were often inverted. The lack of hide ingested by bears would result in the absence of hair in the bear scat. This was the case with bear scats observed at kill sites. Typically, a pile of bones, the hide and the radio collar were found at the burial site. The ribs, scapula, lower jaw bones, cranial bones and leg bones were often found, as well as the detached hoof sheaths. Several scat piles and beds were often found and a musky odour was present.

Unlike bears, wolves scattered the carcass over a wide area, at least 300 m from the kill site, and tended to crush all of the bones, except for the heavier parts of the leg bones and mandibles. Several small bone piles or individual bones were found in the general area. The radio collar of the dead calf was often found 50-100 m from the nearest predator evidence. The mean radius of carcass spread by wolves was significantly greater ($p < 0.01$) than by bears.

Table 3 shows the 8 "best-fit" models derived from stepwise multiple regression analysis with their respective R-square and $C(p)$ values. On the basis of the highest coefficient of multiple determination (R-square) and the lowest Mallows' $C(p)$ statistic, Model 6 (R-square of 94%, the proportion of the variance explained by the regressors) is the preferred model for predicting predator identity at moose calf kill sites in southwest Yukon. The kill site data for 1985 were input to Model 6 to derive a "predicted" predator. The model predicted correctly all 7 cases of wolf predation and all 20 cases of bear predation. Model 1 (predator hair, explaining 83% of the variation in the data), also predicted the predator in each case.

DISCUSSION

The results from this study are similar to those reported from southcentral Alaska by Ballard et al. (1979, 1981). In that study, predators were observed at 48% of the kill sites and bears observed at 79% of those sites. Predator hair was found at all kills, while tracks and scats were common. Lower jaw and cranial bones were often present at grizzly kills, while bones at wolf kills tended to be scattered. Viscera from the prey was present in most wolf kills and missing at grizzly kills. Calf hide was present on approximately one half of the calf carcasses. The results from Ballard et al. (1979) differ from the present study in the following: calf brains, ears, eyes and tongues were often missing at grizzly kills in the Alaskan study and rarely missing in our study. Also, carcasses were buried in only 25% of the bear kills in southcentral Alaska compared to 68% in this study.

Results suggest that the combination of frequent telemetric monitoring of calves combined with collection of sign at kill sites provides an accurate means of estimating predator identity in cases where visual identification of the predator is not made. Also, these results suggest that the single most accurate sign was the presence of hair left by the predator. We caution that the technique is only appropriate where 1 predator visited the mortality site. We were unable to test the predictability of predator identities where multiple predator species sign existed, nor were we able to distinguish between black and grizzly bear sign. These situations would require substantially more complex interpretation.

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Table 1. Summary of occurrences of predator sign at moose calf mortality sites, southwest Yukon, 1983 and 1985.

Sign at moose calf mortality sites	Grizzly & black bear kills of moose calves		Wolf kills of moose calves	
	1983 (_n_=39)	1985 (_n_=20)	1983 (_n_=11)	1985 (_n_=7)
Predator(s) sighted:				
wolf	0	0	2	1
bear	17	10	0	0
none	22	10	9	6
Predator hair type:				
bear	33	16	0	0
wolf	0	0	11	6
no hair	6	4	0	1
Predator track type:				
bear	14	3	0	0
wolf	0	0	8	2
no tracks	25	17	3	5

Predator scat type:					
	bear	29	9	0	0
	wolf	0	0	6	3
	no scats	10	11	5	4
Buried:					
	buried	27	13	0	0
	not buried	12	7	11	7
% prey hide present:					
	≤ 10%	17	9	7	7
	11-89%	3	3	3	0
	≥ 90%	19	8	1	0
Prey's stomach:					
	absent	34	16	2	6
	present	5	4	8	1
	not recorded	0	0	1	0
% prey found:					
	0-15%	27	13	10	7
	16-29%	2	1	1	0
	≥ 30%	10	6	0	0
Radius of carcass spread:					
	0-99m	37	17	5	5
	100-199m	2	2	2	0
	200-299m	0	0	1	0
	≥ 300m	0	1	3	0
	not recorded	0	0	0	2

Table 2. Summary statistics for selected moose calf kill site characteristics, southwest Yukon, 1983 and 1985 (combined).

Sign at moose calf mortality sites	Grizzly and black bear kills of moose calves (mean ± standard error) (n=59)	Wolf kills moose calves (mean ± standard error) (n=18)
% prey hide present	50.5 ± 6.1	14.3 ± 6.7
% of prey found	23.0 ± 4.3	3.7 ± 1.2
Radius of carcass spread (m)	18.2 ± 6.5	122.2 ± 30.1

Table 3. "Best" predictive models of predator identity at moose calf kill sites, southwest Yukon, based on stepwise multiple regression analyses and *R*-square and Mallow's *C*(*p*) criteria for selection.

No. of variables and Model number	Model Component(s)	*R*-square	*C*(*p*)
1	Predator hair type	0.83	61.34
2	Predator hair, tracks	0.90	20.47
3	Predator hair, tracks, spread of carcass	0.92	12.28
4	Predator hair, tracks, spread of carcass, scats	0.93	8.63
5	Predator hair, tracks, spread of carcass, scats, percent hide present	0.93	7.57
6	Predator hair, tracks, spread of carcass, percent hide present, percent of carcass found,		

	carcass buried or not buried	0.94	7.01
7	Predator hair, tracks, spread of carcass, percent hide present, percent of carcass found, carcass buried or not buried, stomach contents present or absent	0.94	7.77
8	All variables	0.94	9.00

Fig. 1. Southwest Yukon Study Area